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LIGHTNING AND THE ELECTRIC TELEGRAPH.

Although scarcely a month passes without considerable and fatal damage being done by lightning throughout the globe, yet a careful analysis of the various cases would perhaps surprise those who have supposed that the destructive effects are particularly noticeable upon the electric telegraph system. We constantly hear of cases where people have been struck and killed by lightning in the open country, but the electric telegraph, which is popularly supposed to be peculiarly subjected to electrical disturbances, so far from being able to give a long list of casualties which have occurred to its operators from this cause, barely numbers its victims by units; indeed, in a recent number of our American contemporary, the *Journal of the Telegraph*, it is stated that a recent fatal case which occurred to a female operator at the Readville Station of the Boston and Providence Railway is the first instance on record of the death of a telegraph operator by lightning. In this instance the circumstances of the case seem to prove after all that the accident was caused by a local discharge, and that the electricity was not conveyed any distance by the wire, as might be supposed.

Cases have occurred where operators have received violent shocks during thunderstorms, but even these are comparatively few in number.

So far from being a source of danger, we are inclined to think that the electric telegraph is rather a cause of safety, as the large net-work of wires spread over the country tends to prevent an accumulation of electricity at any particular point, by continually and silently discharging it to earth. This is particularly the case in districts traversed by main lines where, in this country at least, every pole has an earth wire, running from the top to the bottom, fixed to it.

That these wires effectually discharge a lightning-flash has been seen in cases where the wires have been terminated within a few inches of the top of the pole; a lightning-flash striking one of these destroyed the portion of pole above the wire, but at the point where the wire commenced all damage ceased. The value of these wires is so well known, that they have been adopted in this country for some years past, and in no case has a pole so protected ever been damaged by lightning. Even before it was the practice to employ these earth wires, although damage was done to instruments, no fatal accidents occurred, although the operators were continually employed at the instruments.

The destructive effects of lightning on entering a submarine cable may well be imagined, but yet a very large number of cables are connected to the land lines direct, so that any flash which would strike the latter would inevitably go into the cables, and yet we now never hear of danger being done to the latter. It is true that protectors are interposed between the land wire and the cable, but when we consider the dimensions of such protectors and the destructive effects which are produced on buildings when struck, it seems difficult to understand how, if such discharges struck a line of telegraph, they could be drawn off safely to earth without a large portion entering the cable and damaging it. Perhaps the most striking instance of the immunity of the telegraph system from damage by lightning may be seen in the extensive net-work of wires spread over London, at a high elevation, which one would think would offer the best possible path for the lightning to take; yet we believe the cases of damage are comparatively few, and of accidents to operators entirely *nil*, or very nearly so; certainly no fatal accidents are recorded.

ON RELATIONS BETWEEN CAPILLARY AND ELECTRICAL PHENOMENA.

In a recent communication to the Belgian Academy, M. W. Spring gives some curious facts relating to capillary and electrical phenomena. He enunciates the following two theses:—I. A change in the size of the surface of a body, liquid or solid (the *ponderal* quantity of the body remaining unchanged), is accompanied by a production of static or dynamic electricity. II. The electrification of a liquid body favours a change in the state of tension of its surface.

The following facts are given in illustration:—

1. Two drops of mercury, of the same diameter, are placed on a plane of glass; both are in their natural state. If these drops are allowed to unite, the surface of the new drop is much smaller than the sum of those of the component drops. After union of the two drops, the mercury is electrified so as to be able to attract and retain a pith ball of the weight of 0·000125gr.

2. A thin sheet of caoutchouc is electrified by the maximum tension it can bear without rupture, so as to bear fragments of pith weighing 0.00025gr.

3. Mercury is made to flow from a glass tube fine enough to emit it in drops. The production of these drops involves an increase of the capillary surface. Each drop thus formed is electrified so as to carry 0.0035gr. of pith, independently of the electrification produced by the mercury after its passage through the capillary tube.

4. The quantity of mercury emitted drop by drop in a unit of time diminishes as its electric state increases, and *vice versa*.

5. All other things equal, the quantity of mercury flowing out per unit of time is greater if we hinder the drops from forming at the issue of the liquid from the tube, by putting the tube in mercury, than when the drops can form. Here, in fact, electricity is no longer generated.

6. If we connect by a conducting wire the entrance and mouth of a capillary tube traversed by a current of mercury, a current is observed proceeding from the mouth to the entrance. Under influence of this current, the mercury is rapidly altered by being oxidised. If the conducting wire is of copper, the end inserted in the capillary tube at its entrance is alone amalgamated. A considerable quantity of copper passes at the same time with the mercury.

7. If we fill in free air a capillary tube with acidulated water, and insert one electrode connected with a galvanometer in the upper meniscus (the tube being held vertically), while another electrode is plunged in a vessel of acidulated water below, no current is observed so long as the capillary tube is not immersed in the water of the vessel; but whenever the pendant drop touches the water surface in the vessel, it spreads out, and an instantaneous current traverses the galvanometer.

8. If the water of the vessel be replaced with alcohol, the same phenomenon is observed on immersing the capillary tube charged with water, but with much greater intensity. Further, the alcohol is diffused through the water, and at the moment when it ruptures the upper meniscus in the capillary tube, there is a current in inverse direction to the first; then all comes to rest.

9. A drop of alcohol spreading on water causes the formation of an electric current.

10. If we touch a given surface of water with a body susceptible of being wet, a current is produced at the instant of contact; this current is not increased when the body is immersed in water.

11. M. Spring has constructed an apparatus, which enables to express in weight the thickness of the electric layer of a body. It may thus be described: At a point A on one vertical side of a rectangular glass frame is fixed horizontally a fine glass fibre A B; its extremity B traverses a graduated scale. From near the end of the fibre is suspended with cotton-thread a ball of pith. The graduation of the instrument is done as follows:—The end B of the glass fibre being at zero of the scale, you suspend a milligramme to the end of the thread, and note the extent of deflection of the glass fibre; then suspend two milligrammes, and again note deflection. Thus may be formed a table expressing directly in milligrammes the force excited at the end of the cotton-thread.

In using the instrument, an electrified body is presented to the pith ball; the latter adheres. You then draw down the electrified body slowly and vertically, and the ball follows. When the reaction of the flexion is equal to the electric tension, the ball quits the electrified body and returns to zero. Having marked the maximum descent produced on the scale, one may then express the electric adhesion in milligrammes. By means of this apparatus, M. Spring has ascertained—

12. That the electric tension developed on the surface of a body, by friction, attains, for each body, a maximum corresponding to a given friction. If the friction continues the same in time or in force, the electrical state of the body remains the same, but its temperature goes on increasing with the energy of the friction.

ON THE NATURE OF GALVANIC RESISTANCE.

BY G. K. WINTER, TELEGRAPH ENGINEER, MADRAS RAILWAY.

A RATHER interesting question regarding the nature of galvanic resistance has recently been raised by M. Edlund. It unfortunately happens that the whole of M. Edlund's reasoning on the point is founded upon the supposition that the phenomena of dynamic electricity are due to the actual longitudinal motion of the already hypothetical ether; but it appears to us that, with certain modifications, his theory of galvanic resistance may be made tenable without the necessity of founding it upon an assumption which experiments hitherto made have not only failed to substantiate, but rather have had an opposite tendency. In any case, the less we found our reasoning on uncertain hypotheses, and the more we rely upon well ascertained facts, the greater will be the chance of our deductions being faithful interpretations of the truths of nature.

The question in its simplest form is what is the nature of R in Ohm's law $C = \frac{E}{R}$?

As a general rule, we have hitherto been content to call it resistance, and have ascertained the laws which regulate its quantity, without really inquiring whether we are justified in considering it as actually the resistance which the current encounters in its passage through conductors.

The following very suggestive passage, however, occurs in the Report for 1863 of the Committee appointed by the British Association, to consider the question of Electrical Standards.

"In order to carry on the parallel with the pipes of water, the resistance overcome by the water must be of such nature that twice the quantity of water will flow through any one pipe when twice the head is applied. This would not be the result of a constant mechanical resistance, but of a resistance which increased in direct proportion to the speed of the current; thus, the electrical resistance must not be looked on as analogous to a simple mechanical resistance, but rather to a co-efficient, by which the speed of the current must be multiplied to obtain the whole mechanical resistance. Thus, if the electrical resistance be called R, the work W is not equal to C R t, but to C × C R × t or

$$W = C^2 R t$$

where C may be looked on as analogous to a quantity moving at a certain speed, and C R as analogous to the mechanical resistance which it meets with in its progress, and which increases in direct proportion to the quantity conveyed in the unit of time."

We have here a deduction from the known relations between resistance, current, electromotive force, and work, that the mechanical resistance which the current meets with is R C and not R.

In accordance with this deduction, we shall call R the co-efficient of resistance, as we think this nomenclature preferable to that of Edlund, who names it the principal resistance, and defines it as the actual mechanical resistance encountered by a current of unit strength.

Edlund, who arrives at the same conclusion by quite a different process of reasoning, has so far been anticipated by the writers of the Report; but he goes further than this, and shows that we can consider electro-motive force as an accelerating force, which increases the current until the mechanical resistance encountered becomes equal to the electro-motive force, or until E = R C, up to which time Ohm's law is inapplicable.

The reasoning by which he arrives at this conclusion is perfectly just, if we take it for granted that electricity, or that function of it in whose longitudinal motion we recognise an electric current, possesses inertia. Clerk Maxwell takes the existence of this inertia for granted, for he states in "Electricity and Magnetism," vol. ii., page 182—"Thus, if a current be left to itself, it will continue to circulate till it is stopped by the resistance of the circuit."

This conclusion furnishes us with a clear explanation of a difficulty which has hitherto attended the ordinary interpretation of Ohm's law.

In the equation—

$$C = \frac{E}{R}$$

if we suppose R = o we get a current of infinite strength produced by a finite force. It follows, however, from Edlund's conclusion, that Ohm's law is inapplicable until the mechanical resistance R C becomes equal to the electromotive force E; and as this could never be the case, since R = o, we conclude that it would take an infinite time for the current strength to become infinitely great; so that an exact analogy is established between electromotive force and the mechanical forces.

Another interesting result is the following.

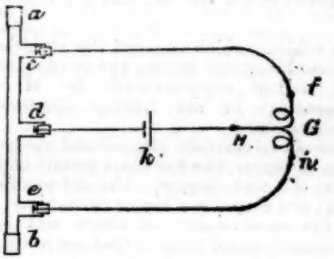
Suppose a current to be divided into a number of paths whose co-efficients of resistance are respectively $r_1\ r_2\ r_3$ &c., then if $c_1\ c_2\ c_3$ &c., are the currents in the path, we shall have, as a deduction from Kirchoff's formulæ—

$$c_1 r_1 = c_2 r_2 = c_3 r_3 \text{ \&c.}$$

Thus the main current would so divide itself, that the mechanical resistance in each of the paths would be equal. Edlund takes this for granted, and deduces Kirchoff's formulæ from it.

It will be seen that this theory of electrical resistance in no way alters Ohm's law, but simply gives a different interpretation to one of the terms involved in it from that generally accepted. It will probably be objected that experimental evidence is required before so radical a change in our ideas can be entertained; this evidence M. Edlund has endeavoured to supply in an investigation described in the *Philosophical Magazine* for February last.

His argument is as follows:—Supposing the mechanical resistance to be due to the relative motion between the ether and the conductor, as his theory requires, then, if motion be imparted to the conductor relatively to the current, the mechanical resistance, and consequently the amount of current flowing, will be modified. To ascertain whether this be so or not he tried the following experiments—



a b is a cylindrical glass tube, of uniform diameter, and furnished with three side tubes *c*, *d*, and *e*; the distances between *c* and *d* and between *d* and *e* are as nearly as possible equal. In each of these side tubes a gold wire is fixed, by means of a cork and sealing-wax, terminated by a gold disc. On each end of the glass tube a metal cap with a screw thread is fastened, by which the glass tube can be screwed into the copper tube through which the liquid to be investigated flows into the glass tube. G is a differential galvanometer, and *k* is a battery. The apparatus is joined up as shown in the drawing.

It is evident that so long as the resistance between *c* and *d* is equal to that between *d* and *e*, and also the polarisation of the plates *c* and *e* equal, no deflection should be produced on the galvanometer. This was found to be the case so long as the fluid in the tube *a b* was stationary. If the fluid (water) is made to flow through the the tube, however, it is evident that in one section of the tube the current is flowing in the same direction as the water, while in the other section the current is flowing in the opposite direction. Care was taken to eliminate as much as possible the interfering action of changes in the polarisation of the discs. It was found that in whichever way the water flowed, or in whichever way the current was made to pass, a deflection was invariably produced in such sense as to show that the resistance of that section of the tube in which the directions of the current and the water coincided was less than that in which they were opposed.

These results were confirmed by another series of experiments, in which the wire *d* H was abandoned, and a rheomotor, with alternating currents, placed between *c* and *f*. So long as the water in

the tube remained at rest, the alternating currents produced no effect on the galvanometer; but directly the water was made to flow, a deflection was produced, showing that those currents which flowed through the tube in the same direction as the water were stronger, and therefore encountered less resistance than those which flowed in the opposite direction. This description will give a general idea of the mode of experimenting, and the results of the investigation.

I hope in a future paper to give a description of my own experiments on this interesting question.

ACTION OF LIGHT ON THE ELECTRICAL BEHAVIOUR OF METALS IN WATER.

This subject, which engaged the attention of M. Edmond Becquerel as long ago as 1839, has lately been studied experimentally by M. Hankel. (Proceedings of the Leipzic *Gesellschaft der Wissenschaften*.)

One of two carefully cleaned and newly-scoured strips of copper was fixed in a porous clay cell by means of a cork-stopper. The cell was filled with water, and placed in a larger glass-vessel containing the same water, in which was immersed the second copper strip, so that one of its surfaces was turned towards the light source. The two strips were connected with the wire of a galvanometer. The glass with its contents was now placed in a black case having a slide, by means of which direct sunlight, or (after insertion of variously coloured glass plates) coloured light, could be admitted to the outer copper plate.

The results with the newly-scoured copper strips were as follows:—On access of free sunlight, the illuminated strip proved negative to the one in darkness, but only moderately so; behind a red glass, the action was extremely small; behind yellow, a little stronger; behind green and dark blue successively, still stronger; whereas behind a very dark violet glass, it became less again.

The copper strips having been oxidised by moderate heating, the following results were obtained:—In free sunlight the illuminated strip was strongly negative; on darkening again, the deflection gradually disappeared; behind red glass the action was less; behind light yellow glass the plate was first positive, then negative; on darkening, it first became still more negative, and then the action disappeared; behind dark green glass the behaviour was similar, but the first positive deflection was less; behind bright blue, dark blue, and violet glass, the plate was equally negative.

Strongly oxidised copper strips were next tested. In free sunlight the illuminated strip was first strongly positive, then weakly negative; on darkening, it was first strongly negative, then the action ceased. Behind red glass the plate was pretty strongly positive, but the deflection of the needle soon fell off considerably; behind bright yellow glass the strip was very strongly positive, but very soon the action diminished; on darkening, a strong negative deflection occurred. Behind dark green glass the plate was first weakly positive, and then negative; behind dark blue glass the copper was also negative, and this change was more considerable than with free sunlight; behind violet glass, the action was similar.

These experiments show distinctly that by strong oxidation the positive condition is favoured, but at the same time, that this is due to the action of the less refrangible rays.

With still greater deposits of oxides and salts on the plates the positive actions were stronger, and they were even to be observed behind the violet glass, though weak and soon gone.

The author describes also the behaviour of copper in sulphate of copper solution, and the behaviour of silver, tin, brass, zinc, platinum; which metals were examined in the same way. For details of these experiments we must refer to the original. The facts communicated afford good evidence of the action of light in development of electricity.

STONES AS CONDUCTORS.

BY M. TH. DU MONCEL.

If, when looking at the jewels displayed in the window of a jeweller, someone were to say that many of the stones, whose polish and colour we admire as we see them in their setting, could be employed as real scientific instruments, capable of indicating variations in the moisture and temperature of the air, we might be inclined to doubt the fact, although there is about it nothing extraordinary, as might be proved thus: Let us take this medallion of yellow opal, having a resinous appearance and dazzling polish; let us ask the jeweller to cut in two the gold circle in which the opal is mounted, and then to reunite the two pieces of the mounting, which has been thus divided, by means of two small pieces of ebonite; the medallion will have become a *thermo-hygrometer*. In order, however, to be able to read its indication, an exceedingly sensitive galvanometer (of 36,000 turns) will be needed, as well as a small battery of the kind used for electric house-bells. We have now merely to suspend the medallion by an ebonite hook in front of a window, to join one of the halves of the mounting to the battery, and the other to the galvanometer, and we shall soon see upon the galvanometer a deflection, which will vary somewhat considerably with the different hours of the day, and which will have a correspondence with the indications of the thermometer and the hygrometer. We shall find, for example, that in summer the deflection being 69° at nine o'clock in the morning, will become 47° at noon; 21° at three p.m.; 23° at six p.m.; 48° at nine p.m.; and 52° at midnight. Now, compare the thermometer and the hygrometer with these variations at the same hours, and the following figures will be obtained:—

	9 a.m.	Noon.	3 p.m.	6 p.m.	9 p.m.	Mid-night.
Stone	69°	47°	21°	23°	48°	52°
Hygrometer	43°	20°	18°	27°	40°	43°
Thermometer	15·8°	18°	19·8°	18·2°	15°	14·8°

The readings of the galvanometer show a

variation which corresponds with those of the thermometer and hygrometer; but as, in these experiments the stone was, at noon, exposed to to the sun, the galvanometer reading fell more quickly from noon to three p.m. than the corresponding hygrometric reading; this shows that the apparatus was affected by temperature as well as by moisture, and that these two causes affect the stone in the same way.

Here, then, we have a trinket transformed into a thermo-hygrometer; but how are these phenomena, which, at first sight, appear so strange, to be explained? One would, at first, have felt sure that hard stones must be excellent insulators; and, in the second place, it is not easy to see what connection there can be between the moisture and temperature of the air, and bodies, such as these stones, which are so little permeable to moisture. Should it be imagined that this conductivity is simply the result of a vaporous condensation on the surface of the stone, such an idea must be speedily abandoned; for if we replace the yellow opal already spoken of by another stone quite as hard and as highly polished (agate, for instance, or even stibnite or cinnabar, which, in spite of their metallic appearance and their richness in antimony and mercury are almost insulators), it will be seen that the greatest deflection due to this vaporous condensation hardly amounts to 4° under the conditions of the preceding experiments, and when the air contains the greatest amount of moisture. It is, then, to the conductivity of the body itself, and to the participation of the whole of its mass in the phenomenon, that we must attribute the galvanometric indications with which we are dealing; but this conductivity is, moreover, as nothing compared with that of some other minerals of the same nature, such as certain silexes (agate and cornelian, for example), which conduct almost as well as distilled water, and are, nevertheless, capable of taking the highest polish, and as hard as a flint. Now, it is with these last-named bodies that I have been able to investigate, in the fullest and easiest manner, this kind of conductivity, as well as the effects upon it of exterior physical causes. It will also be seen that these hard stones, when studied from this point of view, can be made use of as another, and no less useful, scientific instrument, which enables us to readily recognise the nature of the conductivity of a medium through which a current is passed. Let us not, however, anticipate, but proceed with the subject immediately in hand.

I have stated that the greater number of hard stones of a silicious nature, such as flint, agate, onyx, cornelian, opal, &c., are more or less electric conductors, and that the external air, in acting upon them, modifies their conditions of conductivity in such a way, that they can be used as thermo-hygrometers. The demonstration of this effect is very simple. Heat one of these stones in an oven; its conductivity will be, if not completely destroyed, at least diminished to a very great extent; let it now be left in a very dry room, and under a glass shade containing a dessicating substance, such as anhydrous sulphuric acid or chloride of calcium; the conductivity will increase a little in consequence of the stone becoming cooler, but will still be much below what it was originally; let the stone be now placed in a damp cellar and left there, exposed to the damp, for the space of twenty-four hours; when it has been taken out and well wiped it will be found to have regained or even in some case to have surpassed its former degree of conductivity. The purest stones are, then, capable of absorbing the moisture of the air, and this moisture forms in them a conductor, which will be of a better or worse description, according to the greater or less degree of saturation of the atmosphere, and according to the greater or less absorbing power of the stone. On the other hand, as heat acts upon these bodies independently of the absorbed moisture, a kind of psychrometric apparatus, which might have certain applications, is obtained. The way in which the electric conductivity is produced in the case cited is, however, the most interesting question for investigation, for it presents effects of a quite unexpected kind.

In order to get a clear idea of the subject, let us suppose that the setting of the stone, instead of being formed of a circle of gold cut in two, is composed of two pieces of platinum which surround the two ends of the stone, and are pressed against it by means of two clips, the latter being in connection with the two wires of the circuit. Let us take a silex which is a very good conductor, and pass a current through it from a battery of twelve Leclanché cells. The following effects will now be observed:—1st. The intensity of the current will increase as the current continues to pass through the stone; this is the reverse of the effect usually produced in electric transmissions of this kind. 2nd. If, after breaking contact with the battery, the two platinum electrodes are joined to the galvanometer, a polarisation current, in a reverse direction to that of the battery, will show itself, and develope with sufficient strength to enable us to ascertain that under the influence of the original current two generators of electricity have been formed; one of these generators is represented by the electrodes, the other by the stone itself; they will both produce currents, the strength of which is in proportion to the time during which the battery current has been flowing. The relative strength of these currents varies with the nature of the stones, and also with the duration of the electrification. With silexes and stones of the same kind, such as the silicate of copper, certain agates, and quartzes, the currents developed by the electrodes are the strongest, at least with an electrification of short duration; but to observe these currents, the electrodes must be connected by a body of the same nature as the stone employed in the electrification. A metallic connection used for this purpose would fail in producing any current. As for the other currents, to exactly appreciate their importance new metallic electrodes which have been heated and cleaned must be employed. With loadstone, oligist (speculum iron ore), brown zinc-blende, and other stones, which, whilst possessing a very distinct metallic conductivity, are capable of producing very intense effects of polarisation, no currents are produced by the electrodes after the electrification, when they are joined together by a

strip of metal, or by another strip of the same mineral not electrified. On the other hand, the currents developed by the electrified stone, and collected by means of the new electrodes, are relatively intense. Lastly; with moist substances, such as sheets of paper slightly wetted with distilled water, but carefully wiped after damping, the currents produced by these sheets after their electrification are hardly preceptible, whilst those which proceed from the electrodes, which have electrified the same sheets, are very strong. Thus, from the difference of intensity between the currents developed by the two generators thus arranged, it follows, that if the position of the stone or electrified body and that of the electrodes is reversed, we obtain with one class (the silexes and sheets of damp paper) a differential current in the same direction as the original current of polarisation, and with the other (loadstone, oligist, &c.), a current in the opposite direction. Let us now proceed to state the cause to which these polarisation currents are to be referred.

If the arrangements of the experiments has been clearly borne in mind, it will be understood that the metallic electrodes, separated from each other by a stone which is more or less a bad conductor, form, in connection with it, a real condenser, a kind of Leyden jar which, by accumulating a greater or less charge upon the surfaces where the electrodes are in contact with the stone, and by giving rise to a species of electro-tonic conductivity, cause a discharge of longer or shorter duration to take place, when the electrodes are directly connected together after the electrification: this discharge results from the penetration of the charge into the interior of the stone. This current of discharge flows, naturally, in a reverse direction to that of the current which has been employed in the electrification, for it is, in fact, but a return current. It may, therefore, be considered as a current due to the electro-static polarisation of the molecules of the electrified body of low conductivity.

But, on the other hand, with the same arrangement of the electrodes upon the stone, the latter may be placed in the condition of an electrolyte, if the stone is capable of giving an electrolytic conductivity; and under such circumstances the electrodes condense upon their surface the gases produced by the resulting chemical decomposition. These gases, reacting in their turn upon the conductor which has occasioned the electrolytic conductivity, give rise to an electromotive force, which, having a reverse direction to that of the battery current, produces a secondary current or current of polarisation, which shows itself like that above mentioned in a contrary direction to the original current. In the stones of which we have spoken, this conductor, which gives rise to an electrolytic conductivity, certainly exists; for it has been seen that the moisture of the air has much to do with their conductivity, and silexes and other stones of that kind contain, moreover, in their chemical constitution, a certain quantity of water. The two kinds of reaction which we have just passed in review should then be recognised in the effects resulting from the passage through stones of an electric current, and a third may even be produced, the result of another sort of conductivity, analogous to that of metals, and involving thermo-electric effects; but this last only manifests itself in the case of metallic minerals. The latter, besides, only produce the polarisation effects of which we have previously spoken, because being neither pure nor homogeneous, they contain silexes and silicious quartzes, which cause them to partake of the nature of these latter minerals. Let us now see what are the principal effects of conductivity in the various stones, and we shall thereby find that the little system spoken of at the commencement constitutes a small experimental apparatus of a valuable kind for this class of investigation.

If reference is made to what has been previously stated with regard to the currents produced by the electrodes and the stone after they have both been electrified, it will be understood that if an electro-static polarity is developed, a discharge must take place when the polarised parts are connected together by a conductor of any sort. Now, we see that when the connection between the polarised electrodes is made by means of a metallic conductor, no current is manifested; that this absence of current is not due to any failure in the exciting action is shown by the fact that when a stone conductor, which has not been electrified, or a watery liquid, is substituted for the metallic conductor, the current is produced. This proves that the polarisation of the electrodes is due to chemical action, for it is only action of this kind which requires, for the production of a current, that the intervening medium should act otherwise than as a simple conductor. Now this medium, for which either a metallic conductor or a stone having similar properties will not answer, is found in a stone possessing an electrolytic conductivity, such as the silex already mentioned; for the latter allows the gases condensed upon the electrodes to enter into combination. We may, therefore, conclude from these experiments, *that the currents developed by the electrodes arise from an electro-chemical action.*

(*To be continued.*)

CURIOSITIES OF THE WIRE.

From "Chambers's Journal."

A LONDON firm telegraphed to a country agent "Send rails ten foot lengths." The letters "t" and "e" are in the Morse code represented by a dash — and a dot · respectively; but in transmitting this message, the instrument in recording the word "ten" signalled two dots instead of the dash and dot, and the word was thereby converted into "in," the message reading: "Send rails in foot lengths." Mr. Scudamore adds, however, that "if the senders had been less chary of their words, and had written: "Send rails *in* ten foot lengths," which would have cost no more, the blunder would never have occurred." In somewhat the same manner, in a message where the sender asked for a "hack to be waiting him at the station, the letter "h," which is signalled on the Morse instrument by four dots, was converted into

"s," the signal for "s" being three dots; the wayward instrument having failed in one dot, the consequence was that the traveller found a 'sack' awaiting his arrival.

We can imagine the astonishment of the butler, who received a telegram from his master—a certain nobleman—asking him to send at once "*ten bob*," as he was "greatly in need of it." Of course the message had been wrongly transmitted, "ten bob" having originally been "tin box." This story, which happened not many years ago, was told me by a gentleman who was in the telegraph service at that time, and had to deal with the complaint which was made about the matter. The following also comes from the same source. At one of the gatherings held periodically at Braemar, some years ago, a certain earl telegraphed to Edinburgh for a "cocked-hat" to be sent to him at once. In transmitting the message, the article mentioned as wanted was converted into "cooked ham," which was actually forwarded forthwith, greatly to the surprise and indignation of the nobleman.

A telegram was once received as follows: "Please send your *pig* to meet me at the station." Of course it should have been "gig," the instrument having made what, in telegraphic phraseology, is called a false dot, by recording · — — · (P) instead of — — · (G). In fact, it is almost necessary to state, for the credit of the telegraph, that the treachery complained of is, after all, not intentional, but arises mainly from a difficulty which it appears to have in distinguishing the difference between certain letters. This is plainly so in the letters "y" and "x," which the electric wire is constantly confounding one with the other. Over and over again jaded railway officials have been caused fruitless searches after a missing "black boy" through this want of power, on the part of the telegraph, to discriminate between "y" and "x." The stories current on this point are numerous, but the best I have yet heard is the following:—Some time ago a station-master received a telegram from a lady, stating that she had left at his station "two black boys" in the waiting-room, she believed, and tied together with red tape; would he please forward them at once. The astonished official caused search to be made; but instead of "boys" he found two "boxes" in the waiting-room, as described, which were duly forwarded. From a similar cause on the part of the electric fluid, a lady received from her son-in-law a telegram which astonished her not a little. It stated that his wife had presented him with a "fine box."

ON SOME RECENT ELECTRO-CHEMICAL DISCOVERIES.

M. BERTHELOT, the distinguished French chemist, has lately brought before the French Academy of Sciences a series of remarkable experiments, which, in addition to affording other results, point to an important and brilliant discovery relative to the reactions which occur between the gaseous elements of the air and the organic compounds of the earth. The nature and effect of these reactions on vegetation constitute no small portion of the science of agricultural chemistry. And regarding the question of the source of the supply of nitrogen to plants, it is well known that none is more closely enlisting the attention of chemists who find, in the doubt encircling present accepted theories, the stimulus for further and deeper investigation.

We know that, for the support of vegetation, carbon, hydrogen, oxygen, and nitrogen are needed, and that the source of carbon is the carbonic acid which exists in the atmosphere in the proportion of $\frac{4}{3500}$ of its volume. Similarly, the water always present in the air supplies hydrogen and oxygen necessary. It is not so easy to trace whence the nitrogen is derived, and here opinions have fiercely conflicted. Previous to Liebig's time, it was supposed that organic matter (humus) supplied the chief nutriment of plants; but this the great German chemist denounced as "baseless and absurd;" and after detailing his own experimental researches and those of others, he affirms that nitrogen "is derived either from the air, whence it is conveyed to the earth in rain or dew, or from organic substances accumulated from a series of generations of dead or decayed plants, or else from animal remains contained in the earth or incorporated with it by man in the form of excrements. * * * The remains of extinct animal life, which are embedded to an enormous extent in sedimentary strata, or which of themselves constitute whole masses of rock, attest the extraordinary distribution of organic life in the former ages of the earth: and it is the nitrogenous constituents of these animal bodies, passing over into ammonia and nitric acid, which still play an important part in the economy of the vegetable and animal world." Such is the present theory. It is difficult to conceive of its more complete reversal than must follow the acceptance of the facts which M. Berthelot now places before us—facts which the clearest of subsequent investigations must substantiate before they will prevail over Liebig's conclusions—facts which lead to the assertion that free atmospheric nitrogen is fixed in organic nature, unchanged in form by atmospheric electricity.

It has long been known that the silent electric discharge is capable of producing special chemical reactions. In order to study these, M. Berthelot devised a simple little apparatus, composed, first, of a bell-mouthed test tube about which a ribbon of platinum was coiled; and second, a V tube of glass closed at one extremity. The test tube filled with the gas or liquid to be tested was inserted over a mercury bath, and the closed end of the V tube was inserted in it. One pole of a Ruhmkorff coil was attached to the platinum ribbon, the other communicated with a conducting liquid (acidulated water) in the V tube. The current then passed through the then annular space comprised between the vertical leg of the V tube and the inner periphery of the test tube, which space was of course filled with the material under examination. By this instrument he found that organic compounds, at ordinary temperatures, absorb free nitrogen, while under the

influence of the current. In a few hours, 15·4 grains absorbed from 0·24 to 0·3 cubic inch of nitrogen, the greater part remaining unaltered; a solid resinous polymeric product was generated, which, on being heated, decomposed with evolution of ammonia. Turpentine and marsh gas acted similarly. Taking the constituent principle of vegetable tissues—in the shape of a piece of white filtering paper, which is none other than cellulose or ligneous principle—after having slightly wet it, he submitted it to the action of the current in presence of pure nitrogen. In eight or ten hours, a notable quantity of gas had been absorbed, and subsequently the nitrogen, combined with the paper, was extracted in the state of ammonia.

The presence of oxygen does not hinder the absorption of nitrogen. By causing the discharge to act on atmospheric air in contact with a sirupy solution of dextrin, M. Berthelot observed that a certain quantity of nitrogen and oxygen combined with the organic matter. Furthermore, hydrogen is absorbed in the same manner and even more rapidly than nitrogen; 0·06 cubic inch of benzine took up 15 cubic inches of hydrogen, or about 2 equivalents, and the result of the combination was a resinous substance analogous to a dried varnish, possessing a very strong and disagreeable odour.

The reaction produced by the silent discharge appears to be much greater than when the electric spark is used. With the current the proportion of ammoniac gas reaches about 0·03 in the normal mixture of nitrogen and hydrogen; with the spark, but a few hundred-thousandths. The decomposition of ammoniac gas by the current tends to the same limit. This identity of the two limits produced by the inverse action of the current is remarkable, and is as important to be noted as that of the diversity which exists between the action of the silent discharge and that of the spark. Protoxide and binoxide of nitrogen, sulphuretted and phosphuretted hydrogen, sulphurous acid, &c., are all more or less profoundly decomposed; and, in brief, the action of the silent discharge, like that of the spark, tends to resolve compound gases into their elements, with the production of phenomena of equilibrium due to the inverse tendency of recombination. Only, in the case of the discharge, a portion of the isolated elements unites with the compound itself to form condensed products, to the formation of which, however, are opposed the longer duration of the spark, and especially the heating effect thereof.

"It is not doubtful," says M. Berthelot, turning to the practical results of his discovery, "that analogous phenomena (accompanied by an absorption of oxygen) manifest themselves during storms, and even when the air is electrified or presents a different potential in its upper strata and in those exposed to the sun, which is, after all, its normal state. Under these conditions, the organic matters in contact with the air very probably absorb nitrogen and oxygen. This absorption may be revoked at the moment of lightning discharges, which correspond to the differences of tension analogous to and greater than those of the Ruhmkorff apparatus; and the same is likewise probable for weaker differences that are incessantly produced. Perhaps even this absorption of nitrogen and oxygen, joined to the molecular condensations and other chemical changes developed in the tissues under the influence of the electric discharge, causes corresponding physiological modifications which play a certain part in the singular ailments manifested in the human organism during storms."

Without stopping to dwell on these points, however, the discovery may be regarded, as we stated in the beginning, as showing a new cause for the fixing of atmospheric nitrogen in nature. It engenders condensed nitric products, of the order of the humic principles so widely extended over the earth's surface; and however limited the effects may be, at each instant or at each point of the terrestrial superficies, they may evidently become considerable by reason of the extent and the continuity of the reaction universally and perpetually taking place.—*Scientific American.*

Notes.

With regard to the relations between the Telegraph and the Press, the *Saturday Review* remarks on the way in which newspapers which exhibit great enterprise and subject themselves to heavy outlay for prompt and original news are plundered "by the direct connivance of a Government Department." Some London papers, *e.g.*, the *Times* pre-eminently, are at great expense and trouble for telegraphic news. What happens when this valuable news, which has cost so much to obtain, is published? It is at once seized upon by various agencies, who by surreptitious means obtain early copies, and is telegraphed all over the country, so that it may be published there before any parcel from London can arrive. "It cannot be said this is morally an honest system, and at any rate a Government Office ought not to foster it by special facilities at a nominal and unremunerative price." The writer also points out that these Press agencies tend to deteriorate and corrupt the supply of intelligence, by undertaking to supply a vast number of different newspapers at a very low rate, which the present system enables them to do. Newspapers use the same "copy," and independent and original reports are discouraged.

The Working-Men's College in Great Ormond-street was opened on Thursday evening, Oct. 5, when Mr. J. E. H. Gordon, B.A., of Caius College, Cambridge, gave a lecture on "The Characteristics of Modern Physical Research." Mr. Gordon is a representative of the Society for the extension of University teaching in the metropolis, who have lately chosen this College, along with the neighbouring "College for men and women," as one of their centres of operation in London. Mr. Gordon

is to deliver a series of lectures, this session, on "Electricity and Magnetism."

A desideratum at present (it is suggested by the *Scientific American*) is a system of inexpensive blinds, which shall automatically open and shut with the varying intensity of sunlight, so as to admit a uniform amount of light into our reading-rooms, offices, workshops, hospitals, &c. The motive-power should be the sun, whose rays are to be admitted or excluded according to their force or brilliancy. The apparatus might be a system of lightly moving blinds worked by a thermo-electric current, generated by action of the sun's rays on a thermopile. Or the immediate source of motion might be a battery of selenium bars, that metal being electrically sensitive to light.

An account of the Puy-de-Dôme Observatory, which was inaugurated on August 22nd, appears in a recent number of *Nature* (5th October).

M. Germain, of the French Academy, recommends the employment of bobbins of very small resistance, to permit of applying telegraph-wires, in times of storm, for meteorological announcements. Those he describes have a resistance of only 2·8 ohms; they give as much magnetisation as bobbins of 185 ohms, on lines of average resistance; and they are unalterable by the most powerful thunderstorms. The telegraph-wires can be put in communication with the ground, while correspondence is rendered possible.

The Postmaster-General has instructed Mr. Fischer, the controller of the Central Telegraph Station, and Mr. W. H. Preece, to proceed to America, to examine and report upon the telegraphic system of that country, but the date of their departure is not yet fixed.

The interest attached to Mr. Bright's speech in Manchester on the 2nd inst., is attested by the fact that though accommodation could only be provided for thirteen reporters, no less than 371,076 words were telegraphed of the speech to different parts of the country. Of this number 187,559 words were sent through the Press Association, 148,642 by the Central News, and 54,876 by various independent reports. The total number of words represents about 178 columns of matter. The speech was sent direct to thirty towns, including Aberdeen, Belfast, Dublin, and Plymouth. Mr. Bright rose to speak at half-past seven, and yet most of the London and provincial messages, though extending to over three columns a-piece, were completed before midnight.

Professor Melsens, of Brussels, recently constructed a rhe-electrometer on the principle of that of Marianini. It consists of a compass with a coil of wire under it wound on a hollow ebonite cylinder, whose axis is at right angles to the magnetic meridian. One end of the coil communicates with a line of telegraph wire, the other with the ground. A piece of annealed steel wire without polarity is placed in the helix. Immediately the helix receives a current the bar becomes a magnet, and deflects the compass west or east, permanently. A new wire can be substituted for fresh observations. M. Melsens suggested in the Belgian Academy that a system of observations by this means, at a large number of telegraph stations, might throw much light on the electric phenomena above us in the clouds, in our houses, and under our feet in the ground. The hint was acted upon by the Belgian telegraph authorities, and observations are now transmitted regularly from various offices to the central administration. As to the nature of the electrical effects, M. Melsens states that in one observation, during a thunderstorm at Bruges, between 3.48 p.m. and 7.55 p.m., the wire not being changed, the needle passed ten or twelve times from east to west, indicating discharges violent enough to reverse the poles of the wire.

"Strange it is," says a writer in *The Engineer*, "that publishers, so energetic to issue worthless books, do not come forward with a re-issue of Faraday's volumes ["Experimental Researches"]. They are invaluable to the student, they are not out of date, and they can be obtained only with great difficulty—three very good reasons, we should imagine, for a new edition."

Having observed in a number of works in Mayence, that zinc, in many cases, hindered boiler incrustation, but in others not at all or very little, Dr. Rautert was led to examine the feed-water, and he concludes from his analyses that the zinc is efficacious where the water chiefly contains gypsum, but that it fails against carbonate of lime. The proportioning of the zinc to the heating surface alone is a mistake; it should rather be proportioned to the quantity of gypsum present.

The most important improvement recently effected by Mr. Elisha Gray in his electric-harmonic telegraph system (based on the number of vibrations required to give a musical note), is the successful duplexing of his apparatus, so that messages can be sent simultaneously from each end of the line. With the apparatus as now manufactured, four messages can be sent simulta-

neously from each end of the wire. There seems no reason to doubt that the number of circuits operated may be increased to as many as thirty-two (the number of tones and semitones in the musical scale).

According to a comparison lately made by the German Telegraph authorities, there is one telegram sent in Hungary for every eight inhabitants, in Italy and Austria for every six, in France for five, in Germany for four, in Belgium for two to three, in Switzerland for one to two.

The telegraph lines in France had at the end of 1875 an extent of 143,234 kilometres (of which 5,234 were underground). Since 1850 a sum of 38 million francs has been expended on the system. The number of stations has increased at a still more rapid rate than the extent of lines. In 1851, there was one station to 125·5km., in 1855 to 70·44, 1860 to 62·9, 1865 to 37·6, 1870 to 22·7, 1875 to 20km. of telegraph line. In 1861, with a mean cost per telegram of 4·21 francs, the income was 5,631,830 francs, and the working expenditure 6,594,407 francs. In 1875, with 1fr. 65c. as the mean price of telegrams, the income was 15,758,995 francs, and the expenditure 13,612,500 francs.

The Atlantic and Pacific Telegraph Company is introducing the D'Infreville Duplex very generally on its lines, and also uses the automatic considerably on its principal circuits.—The Western Union Company has just declared a dividend of 1¼ per cent. on its capital stock for the quarter ending Sept. 30, which shows that its business is at least not declining.

The Rio Grande do Sul and Monte Video cable has again been interrupted.

The Anglo-American Telegraph Company have resolved (after placing £25,000 to the credit of the renewal fund) to declare the following dividends, all free of income-tax and payable in November next:—An interim dividend of ¾ per cent. on the Ordinary Consolidated Stock for the quarter ending 30th September; an interim dividend of ½ per cent. on the Deferred Stock for that quarter; and a balance dividend for 1876 of 1 per cent. on the Six per Cent. Preferred Stock. No further dividend will be payable on this stock for the year 1876. The interruption in May and the competition of the Direct Company in the last three months probably account for the lessened return.

The Brazilian Telegraph Company pay a dividend of 2s. 6d. per share, making, with previous distributions, 5 per cent. for the year ended 30th June last. The sum of £40,000 is placed to the reserve fund.

The average time in transit between London and India, of all outward messages, *viâ* Teheran, on the lines of the Indo-European Telegraph Company, was for the week ending September 8th, 38 minutes; 15th, 33; 22nd, 55; 29th, 59. The cable between Madras and Penang continues interrupted.

A special meeting of the Eastern Telegraph Company was held on the 9th inst, at which a resolution was passed authorising the directors to acquire and carry into effect, at a cost not exceeding £100,000, the concession from the French Government in reference to the new submarine cable from Marseilles to Algeria, and the land wire through France, with any modification which may be approved by the Board.

NOTES OF TRAFFIC RECEIPTS.

Great Northern Telegraph Company, for September, this year, 400,002 francs (last year, 390,316 francs). Total from January, 3,613,675 francs, as against 3,123,087 francs last year.

Direct Spanish Telegraph Company, for September, £488, against £1,547 in the same month last year.

Cuba Submarine Telegraph Company, 2,174 messages in September estimated to produce £2,000, against 2,072 messages, producing £1,942 in same month last year. Traffic receipts in July, £2,791.

Direct United States Cable Company:—For week ending 23rd September, £3,400; 30th, £3,420; 7th October, £3,750.

West Coast of America Telegraph Company, for four weeks ending 30th June, £2,348.

Submarine Telegraph Company, for September, £10,446; against £10,013 in same month last year.

Eastern Telegraph Company, for September, £33,785, against £30,176 in same month last year.

Electrical Science in Foreign Journals.

DINGLER'S POLYTECHNISCHES JOURNAL. SECOND JULY NUMBER, 1876.

Austrian Railway Telegraphs.

M. KOHLFÜRST has specified the following as necessary in order to the development of the Austrian railway telegraph system:—1. Complete separation of the railway telegraph lines, in construction and maintenance, from the State telegraph lines. 2. Careful supervising of these lines by the railway authorities. 3. Limitation, as much as possible, of the private correspondence on the railway lines. 4. Institution of an office to be filled by a specialist, who should, *inter alia*, un-

dertake the experimental testing of new inventions relating to railway telegraphs, and the supervision of the railway telegraph service. 5. Formation of a committee for telegraph interests in the Verein deutscher Eisenbahn-Verwaltungen. 6. Introduction of exact theoretical instruction on railway traffic and railway telegraph management into the the technical high schools.

FIRST AUGUST NUMBER.

Apparatus for immediate Signalling of a Diminution of Pressure in a Gas-pipe system. By M. RAUPP.

A WROUGHT-IRON vessel containing mercury is closed by a wooden stopper, into which is screwed a brass piece containing a glass-tube, which reaches down into the mercury, and is connected laterally, by caoutchouc tubing, with the main. A steel needle, fixed into the glass tube, with regulating screw at the top, reaches down nearly to the mercury. A battery of two Leclanché elements and with a bell in circuit, is connected, one pole with the wrought-iron vessel, the other with the brass piece. When the gas-pressure is diminished, the mercury rises in the glass-tube to the steel-needle, thus making connection, and causing the bell to ring.

On a New Electric Lighting Instrument. By M. HESS.

THE author has for some time been experimenting with a view to make mining fuses, whose charge should consist of an explosive gas mixture. The electric spark, he finds, easily explodes a mixture of explosive gas and air, and the inflammation is readily communicated to neighbouring inflammable liquids. He was thus led to make an electric lighting instrument, which consists of a small bichromate battery, the zinc plate of which is generally kept out of the acid by a spiral spring,—a small spark-inductor with an electrode knob on the box which holds it, containing the ends of the induction spiral about 0·4 to 0·6mm. apart, while the ends of the primary coil are permanently connected with the battery,—lastly, a flask with a mixture of alcohol and sulphuric ether, in which dips a sponge at the end of a wire. If you want a light, you press the zinc into the acid, then take the sponge and press it against the electrode-knob, whereupon the spark ignites the alcohol-ether. The advantage claimed for this arrangement over those based upon the glowing of wire is its great durability, especially that of the battery. Very weak currents will give induction sparks, and the battery needs revision much more rarely than with glowing wire, which quickly reduces its force.

Renesson's Electro-magnetic Arrangement for stopping Steam-engines.

IN a 25-horse power engine employed by this firm at Sedan, a valve-cock is connected with the distributing box, and on the axis of it is a small wheel on which a weighted cord is wound. The weight tends constantly to unwind the cord and so close the cock, but there is a tooth on the wheel which is stopped by a bolt, until the bolt is withdrawn by electro-magnetic action. A constant, or (better) interrupted current is used, being manipulated at any distance from the engine. The driving-wheel does not make more than 1¼ to 1½ turns after the current is sent.

JOURNAL DE PHYSIQUE.

AUGUST, 1876.

Experimental Researches on Rotatory Magnetic Polarisation. By M. BECQUEREL.

THESE researches were presented to the French Academy in three notes, one of which we have already given in abstract. *Conclusions*:—1. The positive rotation of the plane of polarisation of a luminous ray of given wave-length traversing unit thickness of a diamagnetic substance under the action of magnetism, is proportional to the function $n^2 (n^2 - 1)$ of the index of refraction, and to a factor connected with the magnetism and diamagnetism of bodies. The factor is greater the more diamagnetic the bodies. 2. For bodies of the same chemical family, or for different compounds of the same chemical radical the quotient of the magnetic rotation by the function $n^2 (n^2 - 1)$ of the corresponding index of refraction is a number which varies very little. 3. The chemical nature of the molecules of bodies intervenes directly in the phenomenon in question, and in a complex molecule there may be independence between the effects produced by the various elements composing it. In solutions there is independence between the action of the solvent and that of the body dissolved. 4. Diamagnetic bodies in solution have rotatory magnetic powers sensibly constant, whatever the concentration of the solutions. The negative molecular magnetic rotatory powers increase, on the other hand, very quickly with the approximation of the molecules, in solutions more and more concentrated, and seem to be a function of the intensity of magnetism developed in their molecules through their mutual reactions. 5. The magnetic dispersion of the planes of polarisation of the rays of different wave-lengths by very diamagnetic bodies is sensibly proportional to $\frac{n^2 (n^2 - 1)}{\lambda^2}$, λ being the wave-length and n the corresponding index of refraction. For very magnetic bodies, or which behave as such with polarised light, the negative rotations increase approximately in inverse ratio of the fourth power of the wave-length (Cf. p. 213). M. Becquerel regards magnetic and diamagnetic phenomena not as constituting two distinct properties of bodies, but as due to a single cause.

On the Theory of Condensers, of the Electrophorus, and of Holtz Machines. By M. RIGHI (second note). THIS is an application of former experiments on the penetration of the charge into bodies fixed and in motion. (Hardly suited for abstraction.)

Proceedings of Physical Society of St. Petersburg.—Reserved for separate notice.

SEPTEMBER.

Differential Electro-actinometer. By M. EGOROFF.—Already described, p. 203. A figure of the apparatus is here given.

On the Thermo-Electric Properties of Lime Spar, Beryll, Idocrase, and Apophyllite. By M. Hankel. When a heated crystal is cooled, it presents at its surface an electric distribution variable with the form of crystal. When it has the hemihedry of tourmaline, the two ends of the same axis are charged with different electricities. Apart from this case, the two ends of the same axis have identical properties, but the ends of different axes may be charged with opposite electricities. In particular, in crystals belonging to the system of prism with square base, the faces parallel to the axis of symmetry are not charged with the same electricity as normal or inclined faces limiting the crystal. Two classes of these crystals may be distinguished, according as the positive electricity is carried to the extremities of the axis or to its lateral faces. To the first class belong:—1. Spars of Scheeberg and Freiberg, formed of a hexagonal prism limited by the primitive rhombohedron or one more obtuse. 2. The majority of emeralds. 3. Idocrases of Wilai (Siberia). 4. Apophyllite. On the other hand, very elongated scalenohedra of Derbyshire spar, emeralds of Elba, and idocrases of Ala, belong to the second.

Correspondence.

RESISTANCE OF CONDUCTORS.

Mr. Jacob says he has not found in any electrical text-books a method of measuring the resistance of a conductor, when the positive and negative currents sent through the conductor are of different intensity, and he gives, for this case, a formula which enables one to determine the true resistance of this conductor.

Allow me to say that I have long employed this formula for measuring the resistance of the ground—resistance which it is impossible to obtain directly, owing to the effects of polarisation and local currents which are always developed in circuits completed by the earth. I have published this formula in a *brochure*, "*Sur le Rôle de la Terre dans les Transmissions Télégraphiques*," which I have the honour to send you; and the formula is also discussed in a note inserted in the *Comptes Rendus* of the Academy of Sciences of 28th August, 1876, of which you have given an abstract in last number of your Journal. The *Journal Télégraphique* of Berne has also given it in its number for 25th September. It is true that the calculations which have served in determining it, suppose for the measurement of resistances, the use of a differential galvanometer, while Mr. Jacob bases his on the employment of Wheatstone's bridge. I am glad to see that the two methods lead to the same formula; which is, moreover, very easy of use, and has for long been of real service to me.

The equations which have served me as the base for deduction of the formula in question are, taking Mr. Jacob's designations for the resistances measured by the rheostat, and calling E the electromotive force of the battery, e that of the local current, or of polarisation, which reduces the potential of the earth, r the resistance of the battery—

$$\frac{E\,x}{r\,(x+R_1)+x\,R_1} = \frac{(E-e)\,R_1}{r\,(x+R_1)+x\,R_1} \quad \text{or } x\,E=(E-e)R_1$$

$$\frac{E\,x}{r\,(x+R_2)+x\,R_2} = \frac{(E+a)\,R_2}{r\,(x+R_2)+x\,R_2} \quad \text{or } E\,x=(E+e)R_2$$

From these two equations we have

$$x = \frac{2\,R_1\,R_2}{R_1+R_2}$$

You will perceive that the two formulæ are identical.

Th. Du Moncel.

Lebisey, 5th October, 1876.

A. L.—A.P., October 21, 3·30.—J. J. F. Your supposition appears to be correct.—A. M. Moir. Too late for insertion in this number.

PATENTS.

3617. T. Ward.—"Improvements in railway breaks and signalling apparatus in connection therewith."—19th October, 1875.

3666. J. F. Lackerstein.—"A new or improved telegraph cable."—21st October.

3706. F. J. Pastorelli.—"Improvements in instruments for measuring and recording the velocity of air or other currents, and the speed of vessels moving through water."—26th October.

3727. T. Welton.—"Improvements in portable magnetic appliances in magneto-therapeutics."—27th October.

3762. T. A. Edison.—"Improvements in autographic printing."—29th October.

3772. W. J. Wood and W. H. Shakespear.—"Improvements in train-signalling and in apparatus for the same."—30th October.

3785. W. R. Lake.—"Improvements in metallic alloys or compounds for protecting iron surfaces, and in separating or evaporating apparatus to which such alloys are applied to protect the same from oxidation or corrosion."—30th October. (A communication.)

3789. J. H. Johnson.—"Improvements in motive-power engines, and in apparatus connected therewith."—1st November. (A communication.)

3795. G. Zanni.—"Improvements in magneto-electric signalling, indicating and printing apparatus, applicable for steering vessels, and in signalling, for mining, railway, and other purposes."—1st November. (A communication.)

3798. S. E. Phillips and W. C. Johnson.—"Improvements in telegraph cables."—2nd November.

3807. D. G. Fitzgerald.—"Improved appliances and means for signalling through long submarine telegraph cables and other circuits."—2nd November.

3904. F. Mori.—"New or improved thermo-regulators."—10th November.

3924. H. W. Warden.—"Improvements in apparatus for igniting and extinguishing a number of gas-lamps simultaneously."—11th November.

3976. R. and M. Theiler.—"Improvements in electric telegraphs."—16th November.